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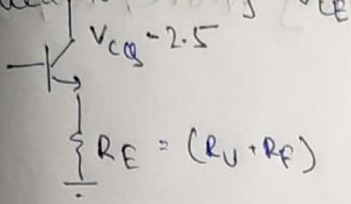
Given $I_{cq} = 5\,mA$

$A = 10 + 10\,(N\%8)$
$= 10 + 10\,(88\%8)$
$= 10$

$V_{out} = 5\,V_{pp}$
$V_{in} = 0.5\,V_{pp}$

1. The output swings up and down by 2.5V from its quiscent point value. When voltage at output is high current available is low so low voltage drop across R_E and high V_{CE}, thus circuit is in active.

However when voltage output is low and swings down by 2.5V current is high and huge drop across R_E. Thus we need to see if V_{CE} is high enough.



We set V_{cq} or $V_{out,q} = 6\,V = \frac{V_{cc}}{2}$ ∴ $R_C = \frac{6}{5} = 1.2\,k\Omega$

It may drop to 3.5 V
I_C (instantaneous) = 7.08 mA
$V_{RE,max} \approx 3.0\,V$ (0.5 drop across V_{CE} at least)
$R_{E,max} = 424\,\Omega$

2. We ~~need~~ don't need such high R_E, we can set bias at 6V safely.
$R_E = 0.1 R_C = 120\,\Omega$ (for stability)

$$|A| = \frac{R_C}{\frac{1}{g_m} + R_U} \qquad \frac{1}{g_m} = \frac{V_T}{I_C} = \frac{26}{5}\,\Omega$$

$$\text{or } 10 = \frac{1200}{\frac{26}{5} + R_U} \qquad R_E = R_U + R_F$$

$$\text{or } 120 = 114.8 + R_F$$

$$\text{or } R_F = 5.2\,\Omega$$

or $R_U = 114.8\,\Omega$

3. $I_B \approx \frac{1}{30}\,mA$
$V_B \approx V_{RE} + V_{BE}$
$= 5 \times 0.12 + 0.7$
$= 1.3\,V$

$$12\,\frac{R_2}{R_1 + R_2} \approx 1.3$$

$$\text{or } \frac{R_2}{R_1 + R_2} \approx 0.11$$

This will lead to some error since we are ignoring base current. Later needs to be fine tuned

First iteration values
$V_{cq} = 6V$ (V_{bias})
$R_C = 1.2\,\Omega$
$R_U = 114.8\,\Omega$
$R_F = 5.2\,\Omega$
$R_2 = 11\,k\Omega$
$R_1 = 89\,k\Omega$
$C_E = 1\,mF$
$C_1 = 47\,\mu F$

The lower cutoff will be determined by C_E

$$f_L \approx \frac{1}{[(R_U + \frac{1}{g_m}) \| R_F]\, C_E \cdot 2\pi} \approx \frac{1}{5 C_E \cdot 2\pi}$$

$$f_L \approx \frac{1}{31.3 C_E} \approx 31.93\,Hz$$

Choosing $C_E = 1\,mF$

Hence in becomes mid band

First thing observed after simulation is that current is too small at about 4 mA. This means R_1 and R_2 needs to be changed. Specifically R_2 must be ↑ and R_1 needs to be ↓.

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A little fine tuning gives

$R_1 = 12.5k$
$R_2 = 87.5K$

current now is 5 mA

V_{out} obtained is 4.88V. Clearly gain is lower than expected. So we can bypass more of R_E by fine tuning. A little fine tuning gives

$R_U = 112\Omega$
$R_F = 8\Omega$

To be safer we can make the gain slightly more/setting $R_U = 112$.

Thus the model obtained is

$R_C = 1.2k$
$R_U = 112\Omega$
$R_F = 8\Omega$
$R_1 = 87.5k$
$R_2 = 12.5k$
$C_1 = 47\ \mu F$
$C_E = 1mF$

Results obtained for DC condition

1. $V_{out} = 5V_{pp}$
2. $I_C = 5.02$ mA
3. $V_b = 1.29V$, $V_C = 5.98V$, $V_E = 0.60V$ → $V_{BE} = 0.69V$, $V_{CE} = 5.38V$

Results for AC analysis

1. $V_{in} = 0.25$ V amplitude peak $= 0.50\ V_{pp}$
2. $A_V = 20.03$ dB ≈ 10
3. $f_L = 477.38$ mHz, $f_H = 50.23$ MHz → 1k is safely within limits of ~~midband gain~~ bandwidth
4. Harmonic distortion obtained $= 0.47122\%$ (according to simulation)

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